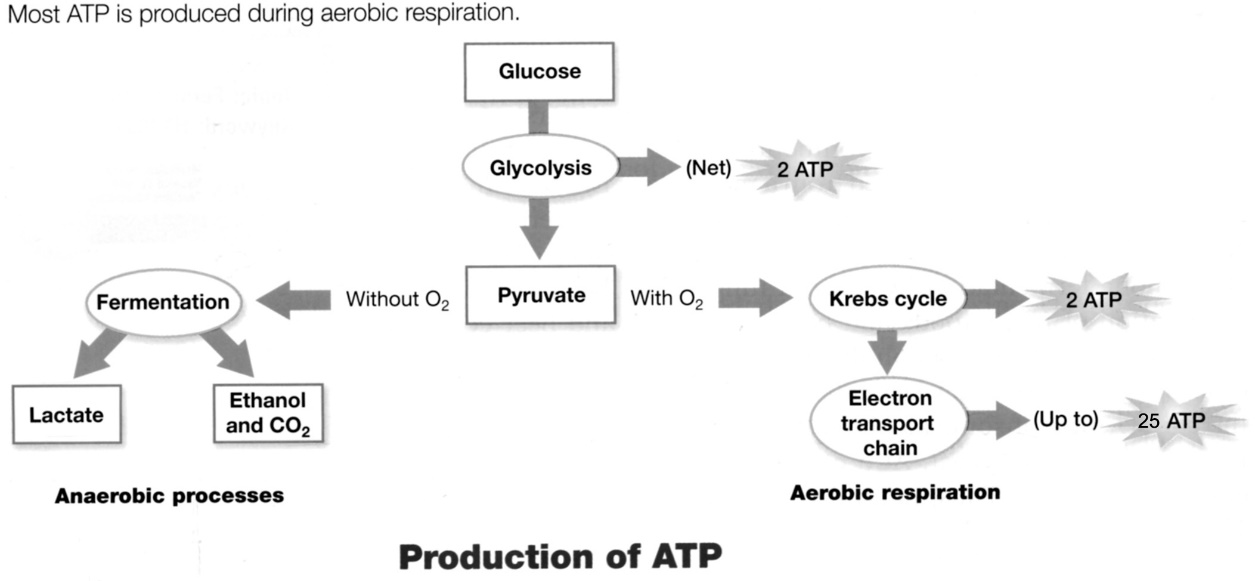
Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Date: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Period: \_\_\_\_

**Exploration:** How does sucrose (sugar) concentration affect the fermentation rate in yeast?

**Background information**

Yeast are tiny unicellular fungi. Humans often interact with yeast but may not realize it. Yeast is used to make bread. This yeast is Baker’s yeast (*Saccharomyces cerevisiae*) and consists of little brown grains. Different types of yeast, such as Brewer’s yeast, are used to make alcoholic beverages including wine and beer. Other species of yeast, such as those in the *Candida* genus, can cause infections in humans.

When O2 is available, cells use **aerobic** **cellular respiration** to transfer energy from the organic molecules in food to ATP. As shown in the figure below, aerobic cellular respiration is a complex process that begins with **glycolysis**, followed by the **Krebs cycle** and the **oxidative phosphorylation** (electron transport chain and chemiosmosis). Aerobic cellular respiration can make up to 38 molecules of ATP\* per molecule of glucose. Most of this ATP is produced during oxidative phosphorylation, during which the electron transport chain can only function if O2 is available as the final electron acceptor.



Under anaerobic conditions, in other words when O2 is not available, cells can make ATP using glycolysis followed by **fermentation**. Glycolysis produces 2 ATP and 2 NADH. Fermentation restores the NAD+ needed for glycolysis to continue as well as producing other by-products (alcohol and CO2 or lactic acid). Glycolysis followed by fermentation produces much less ATP than aerobic cellular respiration, but fermentation is very useful when O2 is not available.

In bread-making, the yeast starts off respiring aerobically, producing water and also carbon dioxide to make the dough rise.

When the air runs out, the yeast begins to respire anaerobically, still making CO2 and now ethanol (alcohol) which evaporates during baking.

The glycolysis and alcoholic fermentation reactions can be summarized as follows:

Glucose -> alcohol + [carbon dioxide](javascript:void(0)) + ATP (energy)

To measure the rate of alcoholic fermentation in yeast, you can measure the amount of CO2 gas the yeast produces. A balloon will be placed on top of the test tube containing yeast and various sucrose concentrations. CO2 production can be measured by:

1. the depth of the layer of bubbles trapped in foam on top of the yeast solution in the test tube tubes and by
2. the circumference of balloons, which get bigger as they catch the CO2 , affixed to the test tubes

Note sucrose is a combination of the simple sugars glucose and fructose. Sucrose is broken down into these sugars before glycolysis.

**Pre-lab questions:**

1. Under anaerobic conditions, yeast carries out glycolysis to produce ATP, followed by alcoholic

fermentation which produces NAD+, \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ and \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

1. What is sucrose? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

🡪Independent variable: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

🡪Dependent variable:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

🡪Control:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

🡪Hypothesis: If the sucrose concentration increases then…\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Experiment**

**Materials**

* Four 15-mL test tubes
* Test tube rack
* Yeast
* 10 mL of warm water
* 10 mL of warm 1%, 5%, and 10% sucrose solutions
* Graduated cylinder
* Four balloons
* Ruler
* Measuring tape
* Marker

**Procedure**

1. Label each test tube: 0%, 1%, 5%, or 10%.
2. To each test tube add 1/8 tsp (0.5 mL) of yeast. Portion out the yeast you are given into four equal parts.
3. Add 10 mL of the appropriate (and warm) water or sucrose solution to each tube. Use graduated cylinder to measure each solution.
4. Put a balloon firmly over the top of each test tube
5. With your thumb sealing the top, shake (but do not invert) each tube until the yeast is dissolved. Be sure not to get liquid into the balloon.
6. Measure the following at 0 min, 5 min, 10 min, 15 min, and 20 min.
   1. Depth of bubbles produced (in cm). Use a ruler.
   2. Circumference of the balloons (in cm). Use measuring tape
7. At the end of the lab rinse out all your test tubes and your balloons and put them back in the designated areas. Make sure your lab area is clean!!

**Data**

Table 1: Depth of CO2 bubbles (cm)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | 0 minutes | 5 minutes | 10 minutes | 15 minutes | 20 minutes |
| 0% sucrose |  |  |  |  |  |
| 1% sucrose |  |  |  |  |  |
| 5% sucrose |  |  |  |  |  |
| 10% sucrose |  |  |  |  |  |

Table 2: Balloon circumferences (cm)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | 0 minutes | 5 minutes | 10 minutes | 15 minutes | 20 minutes |
| 0% sucrose |  |  |  |  |  |
| 1% sucrose |  |  |  |  |  |
| 5% sucrose |  |  |  |  |  |
| 10% sucrose |  |  |  |  |  |

Graph 1: Depth of CO2 bubbles (cm)



Graph 2: Balloon circumferences (cm)



Yeast Fermentation Lab Write-up: Background, Hypothesis, Analysis/Discussion and Conclusion

*Include the following sections:*

**Background**

* + What is yeast?
  + What is fermentation?
  + Under what conditions does fermentation occur?
  + Why is fermentation important?
  + What is produced by alcoholic fermentation?

**Hypothesis**

* If…then…because

**Analysis/Discussion**

* Include a summary of the data (ex. highest, lowest, etc.) to help the reader understand your results. Explain any trends (or lack of trends) in the data.
* Connect results to the process of fermentation.
* Describe possible errors (including inconsistencies) that may have occurred during the experiment. Explain how the error could have affected the data.
* Include adjustments/improvements for future experiments.

**Conclusion**

* Was your hypothesis supported by the data? Explain why or why not.
* Real-world connection

**Sources**

**Rubric**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **Exemplary (3)** | **Accomplished (2)** | **Developing (1)** | **Beginning (0)** |  |
| **Information** | All necessary information is present | Most necessary information is present | Some necessary information is present | Little to no necessary information is present | /3 |
| **Accuracy** | All information is scientifically accurate | Most information is scientifically accurate | Some information is scientifically accurate | Little to no information is scientifically accurate | /3 |
| **Clarity** | All writing is clear and concise; there are no ambiguities or inconsistencies | Most writing is clear and concise; there are no ambiguities or inconsistencies | Some writing is clear and concise; there may be ambiguities or inconsistencies | Writing is unclear and verbose; there may be ambiguities or inconsistencies | /3 |
| **Sources** | Included |  |  | Not included | /1 |
| Total: \_\_\_\_\_\_/10 | | | | | |